SOILS AND SOIL BIOLOGY

Panel Manager - Dr. William Holben
Program Director - Dr. Michael P. O'Neill

The Soils and Soil Biology Program supports research that will further our understanding of the basic mechanisms contributing to the immense diversity in soil chemical, physical and biological characteristics in both managed and unmanaged soils and sediments. The program was developed in recognition that soils provide the interface between the biotic and abiotic components of terrestrial ecosystems. It is in the soil that many of the essentials for the production of biomass are obtained and here that nutrients from decaying biomass are recycled into usable forms.

2000-01104 Trace Elements in Broiler Littered Soils: Fate and Effects on Nitrogen Transformation

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Seed Grant; Grant 2001-35106-10211; $75,000; 2 Years

The broiler industry is rapidly growing in the Southeastern states. It contributes more than $1 billion annually to the economy of Alabama, which ranks third nationally in broiler production. To increase disease resistance, trace elements are routinely added to poultry diets; however, not all are completely absorbed. About 80-95% of some trace elements supplied are excreted in poultry manures. The industry produces an estimated 1.8 million tons of poultry litter per year in Alabama. Application of the litter to farm lands, has resulted in a considerable accumulation of trace elements in topsoils. The objectives of this project are to: (1) study the effects of equimolar concentrations of key trace elements (e.g., As, Cd, Co, Cr, Cu, Mn, Ni, Pb, Se, and Zn) found in broiler litter on N transformation in litter amended soils; (2) assess the effects of temperature on N transformation in the presence of trace elements; and (3) assess the fate of trace elements in sudax (*Sorghum* b*icolor*) grown in trace element-enriched broiler litter amended soils. The research involves laboratory and greenhouse experiments. The information obtained can be used to predict N availability and fate of trace elements in litter amended soils so that long-term strategies can be designed to protect soil biological activity and ensure safe food and feed production in U.S.

2000-00539 Microscale Nitrogen and Carbon Cycling in Biological Deserts Crusts

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New Investigator; Grant 2001-35107-10054; $120,000; 2 Years

Biological desert crusts form in the surface of arid land soils as a result of the growth of desiccation-resistant, photosynthetic and non-photosynthetic microorganisms that trap and bind mineral particles into a cohesive, millimeter thick surface cover. These biological crusts are thought to play passive but major roles in arid land ecology by decreasing erosion and affecting soil hydrology. During periods of water availability, however, these crust are highly active, as indicated by their high rates of photosynthesis and nitrogen fixation, thus potentially and actively influencing the overall fertility of arid lands as well. But the small size of such miniature ecosystems, has made investigations difficult. We plan to use very fine scale analytical tools (microsensors) to describe and interpret the physicochemical gradients that form within these crusts when they are active, as a means to understand the biogeochemical cycling and import/export rates that they sustain, and ultimately, their potential biogeochemical role in arid lands. In this proposal we will focus on microscale cycling of Carbon and Nitrogen, and attempt high resolution measurements of oxygen, pH, ammonium, and nitrate, as well as the assessment of respiration, photosynthesis, denitrification and nitrogen-fixation. It is expected that such knowledge of their internal cycling will be helpful in aiding ecological management of a large portion of arid US rangelands.

2000-00991 Soil N Transformations, Plant N Uptake, and Nitrate Loss After Irrigation Events

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Grant 2001-35107-09940; $226,500; 3 Years

Nitrate production by soil microbes is a problem in many agricultural ecosystems as it leads to leaching and gaseous emission of nitrous oxide and contributes to decreased soil, water, and atmospheric quality. Irrigation events are dynamic periods for nitrate production and loss. At high moisture, microbial mineralization of nitrogen in soil organic matter is rapid, and this causes increased availability of ammonium, which is readily converted to nitrate by microbes. We will test the hypothesis that increased ammonium uptake by soil N microbes and roots after irrigation decreases ammonium availability to microbes who oxidize ammonium to form nitrate, so that nitrate availability is decreased and its loss to the environment is minimized. A comparison will be made between soils managed with high organic matter inputs vs. inorganic fertilizers.

After irrigation events, we will measure: (1) rates of microbial nitrogen transformations, fates of ammonium, and rates of nitrate loss by gaseous emission and leaching, (2) microbial community structure based on phospholipid fatty acids in the soil; (3) ammonium and nitrate uptake by tomato roots in the soil; and (4) factors affecting tomato uptake such as severity of drying of the surface soil between irrigation events, and susceptibility to mycorrhizal symbiosis.

The results will provide information on how soil microbial ecology affects nitrogen availability to plants, and in turn, how plant N uptake may influence ammonium and nitrate fates, including nitrate loss to the environment, in irrigated systems. This information will be useful for improving irrigation and soil organic matter management.

2000-00553 Diversity in the Regulation of Herbicide Degrading Pathways

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New Investigator; Grant 2001-35107-10206; $130,000; 2 Years

Our long-term goals are to study the changes that occur in soil microorganisms when exposed to repeated applications of 2,4-dichlorophenoxyacetic acid (2,4-D). These changes allow efficient degradation of 2,4-D. Though these microorganisms degrade 2,4-D, the huge volume of 2,4-D used in the United States overwhelms the microorganisms causing pollution of water and soil. Examination of how microorganisms degrade agrichemicals, specifically 2,4-D, is important to understanding how using these chemicals effect the environment, both long and short term. The regulation of the pathways for pesticide degradation often limits the substrates that can be degraded by the enzymes of the pathway, yet little is known about the process in which efficient and specific regulation evolves in catabolic pathways. To elucidate these processes we are examining the conservation of regulatory elements for 2,4-D pathways in a diverse group of 2,4-D degrading organisms. First we will examine the degree of functional conservation examining promoter expression in 2,4-D degrading organisms. The second objective will examine the degree of sequence similarity in the tfdR gene that codes for the protein that regulates expression of the genes encoding the enzymes of the pathway. The results of this study will help us to understand how the regulatory elements are assembled after exposure to 2,4-D. Studying 2,4-D degradation will provide information that may lead to bioremediation strategies for agrichemicals that persist in the environment. This information could also be useful in understanding what chemicals microorganisms could adapt to degrade, promoting the development of new, effective, and environmentally friendly agrichemicals.

2000-00534 Influence of Atmospheric CO_2 on Microbial Methane Cycling in a Forest Soil

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New Investigator, Strengthening Award; Grant 2001-35107-10052; $120,000; 2 Years

Methane, CH_4, is a potent greenhouse gas with a biogeochemical cycle closely linked to that of CO_2. Mechanisms regulating CH_4 production and consumption are of concern because its atmospheric level has increased dramatically in recent decades. Methane-oxidizing bacteria form the single largest CH_4 sink, consuming both belowground and atmospheric CH_4, and unsaturated soils are important habitats for these bacteria. However, these microbes may be adversely affected by increasing atmospheric CO_2. To understand these effects in forest soils, we are studying microbial CH_4 consumption at the Forest Atmosphere Carbon Transfer and Storage I site in the Duke Forest, Durham, NC, where open-air plots are exposed to ambient (355ppm) or elevated (555ppm) CO_2. We have found that consumption of atmospheric CH_4 is significantly diminished in these soils, by about 35%, and that soil CH_4 is significantly elevated at shallow depths as well. We have also found relevant changes in soil chemistry and microbial metabolic activity worthy of further exploration. The goals of this project are to understand the roles of methane-consuming microbial activity, abundance, diversity, and spatial distribution, as well as soil moisture, structure, pH, CO_2 content, O_2 content, and temperature, in diminishing the CH_4-consuming ability of these soils. Together, these investigations will reveal ecological mechanisms underlying the observed changes in microbial methane cycling under elevated CO_2, addressing the USDA's goal of promoting the understanding of basic biological mechanisms in plant-soil ecosystems that are essential to environmental quality, with particular relevance to the elucidation of relationships among soil microbiota.

2000-00555 Adsorbate Retention by Soil Organic Matter: Molecular Simulations and Experiment

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Grant 2001-35107-10053; $300,000; 3 Years

The sorption of organic agricultural chemicals to soil organic matter (SOM) is fundamental to their bio-activity, leaching potential, and bioavailability to microorganisms, yet our understanding of the mechanism is incomplete. The classical mechanisms do not apply well to polar compounds, and are incapable of explaining nonlinear behavior, adsorption/desorption hysteresis, competitive sorption in multi-chemical systems, and slow rates.

This proposal offers a collaboration between experimentalists and theoreticians to characterize sorption through the use of molecular modeling coupled with macroscopic physical measurements. It is now possible to probe sorption at the molecular scale using Molecular Dynamics (MD) and Grand Canonical Monte Carlo (GCMC) methods, which are able to simulate both static and dynamic behavior. The compounds will include trichloromethane (grain fumigant), trichloroethylene (formerly used as a solvent carrier), dichlobenil (herbicide), and chloranil (fungicide). Four soils are chosen, two of high- and two of intermediate-organic matter content.

We will construct a computer model of a humic macromolecule and simulate its hydration with water. Macroscopic sorption/desorption experiments designed to compare with the simulation results will be conducted by well-established batch methods to obtain thermodynamic and kinetic parameters. The working hypothesis is that SOM is a three-dimensional phase that has properties similar to the glassy organic state. Sorption will be studied with respect to: prefered locations of molecules; the tendency of molecules to aggregate in voids; effects of sorption on void size and population; rates of diffusion; adsorption-desorption hysteresis; and competitive effects.

This study will help assign mechanism of pesticide interaction, lead to breakthroughs in molecular modeling, and promote wider application of theoretical physics to environmental problems.

2000-00585 Water Flow and Preferential Solute Transport Properties of Field Soils

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Grant 2001-35107-09938; $104,000; 2 Years

Groundwater contamination by agricultural chemicals is a problem of increasing magnitude. The contribution of preferential flow of water and chemicals in relatively large cracks and pores to rapid movement of agricultural chemicals in soil has been reported. There are many theoretical and conceptual descriptions of water and chemical movement in soil. However, currently there are no practical field methods to detect, quantify, and identify the chemical movement processes prior to groundwater contamination. Field measurements to determine both water and chemical movement properties would provide important information concerning the potential for rapid chemical flow before groundwater pollution occurs We propose to develop a simple method associated with irrigation drippers to measure soil water properties at multiple soil locations in thc same time period. At the same time we propose to use a simple method to take soil chemical concentration measurements continuously and automatically in a non-destructive way These measurements will allow us to develop a new method that can quantify both water and chemical movement properties in the field. The new method will be simple to use and it will measure soil properties at multiple field locations. The method is suited to characterize spatial distributions of water and chemical movement properties. Once soil properties are determined, the rate that water and chemicals move through soil can be predicted for various rainfall and weather conditions.

2000-00599. Minimizing Methane and Nitrous Oxide Emissions from Irrigated Rice Fields

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Grant 2001-35107-09941; $192,000, 3 Years

Irrigated rice fields have been identified as the major source of the greenhouse gases methane and an important source of the greenhouse gas nitrous oxide. These two gases are next to carbon dioxide in their warming potential for the earth's atmosphere. The submergence of rice soils and the restriction of atmospheric oxygen to the surface of the soil causes unique conditions that can favor the production of these two gases. Methane is produced only under very biologically reducing (oxygen deficient) conditions whereas nitrous oxide is produced under less oxygen deficient conditions. Preliminary research in this laboratory has shown that conditions might be established in the rice field that will limit the production of both these gases. This can be achieved by controlling the irrigation during the growing season so that the soil does not become reducing enough to produce methane or oxidizing enough to produce nitrous oxide. We will conduct laboratory, greenhouse and field experiments both with U.S. rice soils and in collaboration with the Institute of Applied Ecology of the Chinese Academy of Sciences to test this hypothesis.

2000-00570 An Integrated Assessment of the Bioavailability of Soil-sorbed Pesticides

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Grant 2001-35107-09945; $230,000; 2 Years

A major route of dissipation of soil-applied pesticides is degradation by soil bacteria. This process is advantageous because it prevents accumulation of pesticide residues in soils. When applied to soils, pesticides are typically sorbed by soil solids such as clays and organic matter. This may limit the accessibility of pesticides to pesticide-degrading bacteria in soils. Limited bioavailability may lead to unexpected pesticide persistence hence increasing the likelihood of ground- or surface-water contamination. Several previous studies have reported that sorption to soil decreases pesticide bioavailability to bacteria resulting in increased persistence. Other recent studies indicate that at least some pesticide-degrading bacteria can access the pool of sorbed pesticide, however the influences of soil properties, microbial characteristics and pesticide-soil contact time (aging) on bioavailability are not well understood. The goal of this study is to conduct a comprehensive assessment of the bioavailability of soil-applied pesticides to bacteria. This will be achieved by measuring the simultaneous processes of pesticide sorption, desorption and biodegradation in soils and determining how soil and microbial characteristics, and aging, influences these processes. Newly developed mathematical models will be used to describe the interaction among these processes in an integrated fashion. Knowledge of pesticide bioavailability is needed to improve risk management associated with pesticide use in agriculture, and to maintain the quality of our soils and water.

2000-00588 Towards an Understanding of the Untapped Microbial Diversity in Soils
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Grant 2001-35107-09939; $330,000; 3 Years

Soil is perhaps one of the largest reservoirs of microbial life on the planet, and the acreage of soil being converted to agricultural use is increasing. However, knowledge of the composition, organization and fluctuations of indigenous microbial populations in soil ecosystems is scarce, even though the metabolism of such microbes drives many ecosystem-level processes and undoubtedly has a significant impact on crop productivity. One reason for the paucity of data on microbial communities in soil has been the general inability to grow in pure culture the majority of microbes visible in microscopic examinations of soil. By using the techniques of molecular biology to characterize DNA that is purified from soil, we have circumvented the requirement for cultivation and have obtained an illuminated view of the remarkable microbial diversity that actually exists in soil. Unfortunately, this approach has provided little insight into the physiology and ecology of the corresponding microbes.

A better understanding of the physiological ecology of these microbes and their impact on soil processes will only be attained when they are obtained and studied in pure culture and in defined mixed cultures. Accordingly, we propose to integrate refined procedures for microbial enrichment and isolation with molecular biological methods and process-oriented microcosm studies to characterize the as-yet-unexplored and largely untapped microbial diversity in soil. The proposed field site for the research is the Kellogg Biological Station Long Term Ecological Research site in Agricultural Ecology at Michigan State University.

2000-00558 Phosphate Retention in Mixed Mineral Systems as Affected by Redox Potential
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Grant 2001-35107-10179; $190,000; 2 Years

Concern over declining water quality caused by nutrients such as nitrogen and phosphorus in agricultural runoff is a major issue in the U.S. and worldwide. The USDA Natural Resource Conservation Service has developed a policy for states to implement plans for reducing the environmental impacts of phosphorus from animal waste and fertilizers applied to soils. Such plans would require the development of practices that minimize losses of phosphorus from agricultural lands to surface waters. For example, it is known that wetlands can reduce negative impacts of nitrogen, but the role of wetlands in reducing the impacts of phosphorus is not well understood. Often when a soil becomes more wet, such as after sustained rainfall or when agricultural land is converted to a wetland, iron-oxide minerals in the soil dissolve and any phosphorus bound to these minerals is released into the soil water. The transport of this released phosphorus to a stream could deteriorate water quality. However, in many soils, the released phosphorus may bind to certain types of aluminum-oxide minerals if these minerals are present in sufficient quantity. This research is aimed at determining how phosphorus is transferred between iron- and aluminum-oxide minerals or released into water under conditions that simulate wetting and drying of soil. The results will help us relate mineral properties of a given soil to the ability of that soil to protect water quality by binding phosphorus under wet conditions.

2000-00531 Diversity and Activities of Soil Microflora and Mesofauna: Influence on Soilborne Pathogenic Fungi

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New Investigator, Grant 2001-35107-10180; $214,000; 3 Years

Soil contains the largest diversity of all terrestrial ecosystems, especially microorganisms and mesofauna. However, this diversity is poorly quantified, and its relationship to ecosystem functioning is not well understood. Here, we propose to examine the relationships between the diversity and activities of soil microorganisms and stability of soil biological systems. Stability of soil biosystems will be measured by assessing activities of two plant pathogenic fungi, *Pythium ultimum* and *Rhizoctonia solani*. Three major questions guide this research: (1) Does diversity of soil microorganisms and mesofauna increase as intensity and frequency of disturbance decrease and resource availability increase in alternative agroecosystems? (2) Do high activities and diversity of soil microorganisms and mesofauna reduce activities of root pathogens? (3) Does the increase of diversity and activities of soil microorganisms and mesofauna enhance the resistance of soil biosystems to introduced pathogens? To expand the generality of findings, experiments will be carried out in two settings, one in soils of five adjacent ecosystems along the disturbance gradient, and another in four different types of soils. This study will advance our understanding of the relationship between soil diversity and the stability of soil biosystems. Since soilborne plant pathogens often cause extensive damage to many crops, knowledge of the effects of soil microorganisms on plant pathogens will also help us design better practices that reduce crop damage caused by these pathogens in sustainable agriculture.

2000-00538 Mechanisms of Halobenzoate Degradation by Denitrifying Bacteria

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Grant 2001-35107-09944; $180,000; 2 Years

Halogenated aromatic compounds constitute one of the largest groups of environmental pollutants, partly as a result of their wide spread use as herbicides, insecticides and fungicides. Because pesticides are deliberately introduced into the environment, it is important to understand the consequences of potential adverse effects such as environmental contamination. Microbial degradation is one of the key factors that effects the ultimate fate of pesticides in the environment. Detailed information on the dehalogenation and degradation mechanisms and of the microorganisms involved is pivotal to understanding the fate of these compounds in the environment and evaluating potential hazards to human and environmental health. Knowledge of dehalogenation biodegradation mechanisms is also needed for effectively implementing bioremediation technologies for cleanup of contaminated soils and sediments. The long term goal of our laboratories is to investigate the metabolic diversity of denitrifying bacteria capable of degrading halogenated aromatic compounds. The overall goal of the proposed study is to investigate the metabolic diversity of bacteria capable of degrading halogenated benzoic acids under denitrifying conditions, and to examine the mechanisms for dehalogenation and degradation. The study will provide fundamental information on the microorganisms involved in anaerobic degradation of halogenated aromatic compounds and expand our understanding of anaerobic biodegradation and dehalogenation mechanisms.

2000-00568 CO_2 Emissions from the Dissolution of Soil Carbonate as a Contributor to Greenhouse Gases

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Strengthening Award; Grant 2001-35107-09943; $142,500; 3 Years

The amount of CO_2 in the Earth's atmospheres continues to rise at a rate of about 0.5% per year. In the United States, the CO_2-carbon emission is about 1442 x 10^{12} grams of carbon per year. Consequences of the CO_2 increase as a greenhouse gas are controversial and have stimulated much scientific research. For example, research on carbon sequestration in agricultural soils has shown that U.S. cropland might be capable of sequestering about 75 to 208 x 10^{12} grams of atmospheric carbon per year. Grazingland soils in the U.S. might be capable of sequestering 36 to 111 x 10^{12} grams of carbon per year.

In grazingland soils, much of the carbon exists as soil carbonate ($CaCO_3$). Soil carbonate, however, in addition to being a potential sink for atmospheric CO_2, is a potential source for atmospheric CO_2, which would result when carbonate is dissolved by acidic rain or microbiotic crust. The objective of this study, therefore, is to determine if CO_2 is released into the atmosphere from exhumed soil carbonate in New Mexico. Subsequent studies will focus on rangeland management that can curtail CO_2 losses from carbonates, if any, and promote carbon sequestration in vast areas used for grazing in the United States and similar regions of the world.

2000-00598 Fungal Biology of Fine Root Decomposition in a Northern Hardwood Forest

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Grant 2001-35107-10167; $251,000; 3 Years

Fine root turnover is a large component of northern hardwood forest carbon budgets. However, the biota responsible for the processing and ultimate fate of the large quantities of C and essential nutrients stored in dying roots have not been comprehensively identified. The goal of proposed research is to improve our understanding of the microbiology and ecology of fine root decomposition. We will identify decay fungi in fine roots and investigate in more detail the colonization and decay of fine roots by different fungi, in the northern hardwood forest ecosystem at the Hubbard Brook Experimental Forest, NH. Our specific objectives are to (1) identify decomposer fungi found in decaying fine roots and characterize their distribution among fine root categories; (2) examine temporal patterns of fungi inhabiting dead roots; and (3) test effects of rhizosphere disruption on the decomposer community

Fungi in dead roots will be surveyed using culturing and molecular genetic techniques. We will characterize the breadth of diversity of fungi involved in the process of root decay. We will also examine patterns among decomposer organisms for types of roots (mycorrhizal type, soil horizon, diameter). We will use root windows for microscopic examination and for sampling of decay fungi over known time-courses of root death and decay. This research will improve our knowledge of some of the wide variety of decay fungi present in forest soils. It also will advance our knowledge of the relationships between fungal species composition and patterns of decomposition for fine roots.

2000-00525 Microbial Contributions to Carbon Sequestration in No-Tillage Agroecosystems

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Grant 2001-35107-10166; $201,500; 3 Years

The purpose of this proposal is to investigate the interactions between microbial community structure, soil aggregation, and the formation and stabilization of microbial-derived soil organic matter in no-tillage compared to conventional tillage agroecosystems. We will use a combination of field observations and laboratory experiments to evaluate (1) where bacterial and fungal-derived organic matter is located within the soil aggregate structure, (2) the factors controlling fungal: bacterial biomass ratios and the relative accumulation of bacterial and fungal cell wall products, and (3) whether microbial community structure, particularly the relative abundances of bacteria and fungi, influence the overall production and degradation of microbial-derived organic matter. Bacterial and fungal cell wall constituents (muramic acid and glucosamine) will be measured to quantify the relative contributions that bacteria and fungi make to the production and stabilization of microbial-derived soil organic matter. ^{13}C-labeled substrates (glucose or plant residues) will be used to trace the movement of substrate carbon into bacterial and fungal products and to examine rates of bacterial versus fungal product decomposition. This research will focus on the interactions between microbial community composition, soil properties (e.g., texture, aggregation), and carbon stabilization and will provide information relevant to the maintenance of soil fertility and to the development of sustainable agricultural systems that can, through sequestration of soil carbon, help mitigate rising atmospheric CO_2 concentrations.

2000-00569 Microbial Transformation of Arsenate and Selenate

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Strengthening Award; Grant 2001-35107-10055; $110,000; 2 Years

Selenium and arsenic have become increasingly significant as environmental toxins in agricultural soils and drinking water. Their transformation (i.e., reduction and oxidation) and mobilization can be strongly influenced by microbial activity. The detection of arsenate and selenate-respiring bacteria in numerous pristine and contaminated environments and their rapid appearance in enrichment culture suggest that these organisms are widespread in nature. Furthermore, the microbial production of the more toxic species selenite and arsenite could be significant in agriculture soils and livestock (i.e., rumen). *Sulfurospirillum barnesii,* a strict anaerobic bacterium isolated from a selenium contaminated freshwater slough, can grow by respiring selenate, arsenate, and nitrate. The P.I. has identified components of the pathways involved in each of these reductive pathways; developed successful purification schemes for the main components (i.e., terminal reductases); and further developed an enzyme assay to detect selenate and arsenate reductase activity. The objective of this proposal is to complete the biochemical characterization of the selenate and arsenate reductase pathways in S. *barnesii,* and develop biochemical and molecular probes. Antibodies raised against specific subunits of the terminal reductases will be used as biochemical probes. Molecular probes and PCR primers will be designed from the genes encoding the major subunits of the reductases. The results should elucidate the biochemical mechanism of selenate and arsenate reduction in S. *barnesii,* and provide diagnostic tools for use in assessing the role of bacteria in the mobilization of selenium and arsenic in natural environments.

2000-00536 The Environmental Fate of Arsenic From Poultry Litter
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Grant 2001-35107-09942; $164,500; 3 Years

Two organo-arsenic compounds, p-arsanilic acid and roxarsone, are commonly used feed additives in the poultry industry for prevention of coccidiosis, increased weight gain and improved feed efficiency. Because these compounds are not readily adsorbed by poultry, arsenic in poultry litter can reach concentrations greater than 41 mg kg-1, which, for comparison, is the maximum allowable concentration for land application of sewage sludge according to USEPA 503 regulations. Broiler poultry litter is a valuable agronomic resource and greater than 90 % of the 13 million Mg of poultry litter annually produced in the U.S. is applied to land, however, the fate of As from poultry litter needs to be addressed.

This study focuses on the environmental fate of these organo-arsenical compounds in the litter and when the litter is subsequently land applied. Little is known about the biogeochemistry of these arsenic compounds but it is clear that a number of biotic and abiotic transformations that could change As speciation are possible both during litter storage and after land application. Biologically mediated formation of volatile arsenic compounds has been proposed as a pathway for As loss from the soil profile; however, the competing process of biologically mediated mineralization could result in the formation of the more toxic inorganic As species, which may accumulate in the soil. We hypothesize that changes in soil chemical properties associated with application of poultry litter may enhance the solubility of As and that mineralization of organo-arsenicals may be a more important process than volatilization. The results of this research will provide valuable information on As bioavailability in poultry litter-amended soils that will assist in selecting management practices that minimize adverse environmental impacts.

2000-01135 SDSU Soil Chemistry Project - Atomic Absorption Spectrophotometer
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South Dakota State University; Plant Science Department; Brookings, SD 57007
Equipment Grant; Grant 2001-35106-09937; $39,640; 2 Years

The accumulation of heavy metals and trace elements in localized areas can be a potential threat to human health and our environment or in special instances, such as selenium, a resource for adding extra value to our agricultural products. The Soil Chemistry Project at South Dakota State University is involved in several investigations studying the beneficial aspects of trace element accumulations to agriculture productivity as well as the potential threat to the environment posed by these elements and heavy metals. The overall goal of these projects is to determine where these elements are concentrating, how they move in our ecosystems and how to limit or encourage their entry into the food chain. Specific projects include: (1) the effects of waste disposal (municipal & animal) on soil quality and plant production; (2) the ability of agronomic and non-agronomic plant species to take-up and accumulate Se (which is nutritionally required by animals) and heavy metals, changes in soil quality when former CRP land is managed for biomass production, and soil survey/characterization for trace element and heavy metal distribution. The awarded funds will be used to help purchase an atomic absorption spectrophotometer which will provide the Soil Chemistry Project with the capabilities to quantify elements such as cadmium, chromium' copper, molybdenum, selenium. Lead, and zinc in soils, water, and plant tissue. The detection limit on some of the metals will be in the part per billion range. Equipment with this type of capability is not currently available in the Plant Science Department.

2000-01161 Acquisition of a Scintillation Counter with Solids Capability
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Equipment Grant; Grant 2001-35106-09910; $25,190; 1 Year

Humin is an insoluble organic matter fraction that usually represents more than 50% of the organic carbon present in a soil. The majority of pesticide residues bound to the soil (i.e., greater than 50%) are bound to this material. For these reasons, understanding the binding phenomena is vital to developing a predictive understanding of the fate and transport of pesticides in the environment. Typically, the processes involved in bound-residue formation are monitored using radioactively-labeled pesticides. The ability to analyze solid samples is essential because humin is, by definition, and insoluble fraction of soil organic matter. As such, the radioactivity associated with can not be measured using liquid scintillation courting methods. The instrument requested in this proposal will be used in an ongoing research program to study the nature and formation of bound pesticide residues in soil, and particularly in the humin fraction.

2000-00537 Ketogluconate: Solution Chemistry, Adsorption-Desorption, and Impact on Mineral Solubility

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Grant 2001-35107-10165; $187,000; 3 Years

Low-molecular-weight organic acid anions, such as 2-ketogluconate, are plant root and microbial exudates that are common to the soil solution 2-Ketogluconate can constitute up to 20% of the total components present in the rhizosphere, with higher concentrations observed in manure-amended soil and in soils that are deficient in bioavailable phosphorus. Literature and our preliminary studies indicate that this compound has the potential to increase metal solubility and mobility, either through metal cation complexation or by hindering mineral crystallization and growth. However, despite the apparent prevalence and potential impact of 2-ketogluconate on soil solution and solid-phase chemistry, there exists no critically evaluated information on its metal-complexation chemistry, its ability to enhance mineral solubility by inhibiting crystallization, or its adsorption-desorption behavior. The objectives of this proposed research seek to elucidate the chemistry of 2-ketogluconate and to enhance our ability to predict the fate and behavior of components in the soil. A technique will be developed for the analysis of 2-ketogluconate in simple and soil systems. The acid dissociation constant will be determined, as will the ion association constants for the formation of 2-ketogluconate complexes with various trace (Cu, Cd, Pb) and major (K, Ca, Mg, Al, Fe) metals. The mechanisms by which 2-ketogluconate hinders the precipitation of Al and Fe(III) (hydroxy-) oxides and phosphates will be identified. The adsorption-desorption behavior of 2-ketogluconate on common soil minerals in the presence and absence of competing organic and inorganic ligands will be investigated.

2000-01152 Equipment Grant Proposal for an Anaerobic Chamber

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Equipment Grant; Grant 2001-35106-10051; $11,310; 1 Year

Faculty at the University of Tennessee at Chattanooga (UTC) are engaged in research that investigates the accumulation and speciation of nutrients, metals, pesticides, and agriculturally related organic pollutants in soils and sediments. Anaerobic processes can significantly influence the fate and bioavailability of nutrients and agricultural products in the environment. Increased understanding of anaerobic processes and their influence on agricultural products is necessary to meet USDA research directives to "objectively evaluate and predict the effects of natural and human-induced environmental change... on natural and managed ecosystems, son's, and water resources," that in turn provide for "effective management strategies and to the formulation of policy decisions based on sound science." (USDA, NRI)

Sediments and soils are complex systems of biological and chemical processes that experience constant or fluctuating anoxic conditions. The study of anaerobic processes on nutrient and agricultural product transport and fate requires laboratory conditions devoid of oxygen. Acquisition of an anaerobic chamber will enable UTC to study organic pollutant, heavy metal, and nutrient transformations and to address total pollutant fate in aerobic and anoxic zones. Maintenance and operation of the chamber will be overseen by Dr. Guthrie (P.I.) and Dr. Spratt (Co-P.I.). Acquisition of an anaerobic chamber will expand research opportunities for UTC faculty (Biology/Chemistry Departments), for UTC students, and for adjunct faculty at the Southeastern Aquatic Research Institute (SART). Funding of this equipment grant would also increase the competitiveness of UTC faculty by providing strategic equipment necessary for proposed microbiological and chemical research relevant to USDA concerns.

2000-00546 Determination of Transport Parameters in Coupled Heat and Moisture Transport in Soils Using NMR

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Grant 2001-35107-10182; $236,500; 3 Years

This study investigates the coupled transport of heat energy and moisture in soil using noninvasive measurements of the moisture content and temperature field in a soil sample taken by nuclear magnetic resonance (NMR) techniques in combination with inverse methods for the determination of transport parameters. The movement of soil water and heat energy is important for environmental processes such as evaporation, and agricultural processes such as seed germination. NMR has been used to measure soil moisture content in the laboratory; we will extend NMR methods to measure temperature in porous media, so that simultaneous noninvasive measurement of soil moisture and temperature will be possible at a spatial resolution unavailable before. The PIs will develop an appropriate experimental methodology (NMR pulse sequences, measurement calibrations and analyses, heating methods, etc.) for microscale measurements of moisture and temperature fields in sample porous media over the time period of a soil drying experiment. The microscale measurements provided by the proposed experiments are needed to accurately resolve the driving gradients of transport of water and heat energy, which often exist below the measurement scale of conventional instrumentation. The data sets will be used to determine heat and moisture transport properties using inverse methods. A goal of this analysis will be the determination of the entire functions that represent the properties, without use of unwarranted assumptions regarding the functional representations. These microscale-derived transport coefficient functions can be compared to transport function derived from bulk-sample measurements, and will also provide insight into the utility of theoretical approaches, such as volume averaging, to the determination of transport coefficients.

2000-00594 Hydraulic Conductivity of Unsaturated Porous Media - Film and Corner Flows in Angular Pore Space

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Grant 2001-35107-10181; $229,500; 3 Years

Prevention of groundwater pollution and remediation of contaminated water resources require in-depth understanding of flow and transport processes in the unsaturated zone. Empirical models for media hydraulic properties offer satisfactory predictive capabilities for wet conditions but often fail under relatively dry conditions (common in many arid and semi-arid regions). The primary objective of this study is to develop a novel approach for predicting the unsaturated hydraulic conductivity function (a key component for obtaining predictions) based on improved picture of liquid configuration and flow within a realistic geometry of media pore spaces. An idealized representation of media pore space using angular pores connected to slit-shaped spaces with internal surface area is proposed as an alternative to the conventional bundle of cylindrical capillaries representation. Equilibrium liquid configurations are calculated by considering the individual contributions of film adsorption and capillary condensation to the matric potential. Building upon these developments we propose to introduce hydrodynamic considerations into the resultant equilibrium picture towards the development of more realistic models for unsaturated hydraulic conductivity. The proposed work will provide a rational basis for considering the important interplay among viscous, electrical and molecular forces that operate within thin liquid films. The study will improve understanding of complicated behavior of pollutants and microbial activity at larger scales of interest. Finally, the results should greatly enhance ability to model transport processes and plan remediation activities at low water contents and improve predictive and management tools for water and agricultural land resources.

2000-00906 Ecology of Phloroglucinol-Producing Pseudomonads in Take-AII Suppressive Soils

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Grant 2001-35107-10111; $215,500; 3 Years

Take-all is the most destructive root disease of wheat worldwide. There are no varieties resistant to take-all, and chemical controls are limited. The need for U.S. agriculture to become more sustainable has necessitated the development of alternate methods to control root diseases. Take-all decline (TAD) is the spontaneous decrease in the severity of take-all occurring in fields with monoculture wheat or barley after a severe outbreak of the disease. This natural biocontrol of take-all is an example of a disease suppressive soil. Suppressive soils control soilborne pathogens without the application of chemical pesticides. TAD occurred because of the build-up of a specific group of bacteria known as fluorescent pseudomonads, which produce the antifungal metabolite 2,4-diacetylphloroglucinol (DAPG). DAPG is produced in very minute quantities in sites on roots where the take-all pathogen infects. This is the first time that the molecular basis of any suppressive soil has been defined. The objectives of this proposal are to evaluate the relationship between the genotype of DAPG producers and their ability to colonize roots and suppress disease; to determine whether nonsuppressive fields can be converted into a suppressive state by introducing DAPG producers; and to determine the impact of other rhizosphere microorganisms on DAPG producers and soil suppressiveness. The finding from this study are expected to greatly expand both the understanding of disease-suppressive soils and their use in systems of sustainable agriculture.

2000-01120. Enhancing Soils Research Capabilities with a Tekmar-Dohrmann Total Carbon Analyzer

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Equipment Grant; Grant 2001-35106-09909; $22,710; 1 Year

The Soil Science Group from the Department of Renewable Resources at the University of Wyoming is requesting funds to purchase an instrument (Tekmar-Dohrmann Phoenix 8000 Total Carbon Analyzer) that measures organic carbon in soil and water samples to enhance our research capabilities. Principal users of this instrument will be will be the Soil Science Group but its use will be made widely available. Primary uses of the instrument will be studies of microorganisms in soil as well as organic materials in soil and water. The requested equipment will increase our scientific productivity and make us more competitive in securing funding for future research.